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MEASURING SOURCE REDUCTION: VARIABLE RATES/PAYT AS AN EXAMPLE

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Executive Summary / Abstract

Source reduction is the highest priority on the solid waste management hierarchy, but the contributions these programs have made toward waste reduction have proved challenging to measure. This project proposed and developed two major types of methods for developing quantitative measures of the solid waste tonnage diverted by source reduction. One approach was based on using data from one point in time; the other was based on data collected over a series of years. To demonstrate the measurement technique(s), we needed to select a source reduction program as a test. We estimated the source reduction impact from a program with previously unmeasured source reduction impacts – variable rates or "Pay as you Throw" programs (VR/PAYT). These incentive rate programs have been demonstrated to increase recycling and yard waste diversion, but the level of benefits from source reduction were unknown. Variable rates / PAYT were selected as the test program because the estimated source reduction benefits are immediately relevant to the thousands of communities across North America with VR/PAYT programs. We were successful measuring the source reduction benefits from the programs using each of the two methods, and found the techniques developed similar order of magnitude results. We also developed estimates of the cost-effectiveness and simple paybacks associated with VR / PAYT programs – estimates that take into account the fuller benefits of the programs, incorporating source reduction alongside other benefits. The project demonstrates that source reduction from programs can be measurable, and the evaluation shows that at least some of these programs can be a very cost-effective part of the mix of solid waste management programs and policies at the community, state, or nationwide level.

Introduction

The standard solid waste hierarchy places source reduction (SR) or waste prevention as the most preferred method of solid waste management. However, dedicated efforts toward these programs have been hampered by the difficulty associated with measuring impacts of these programs. SR programs have received less attention than recycling and yard waste programs. A key reason is that source reduction is something that "doesn't happen". Measuring something that *didn't happen* can be troublesome, uncertain, and data intensive. And if the impact is difficult to measure it is even harder to try to justify and evaluate project efforts and expenditures, especially in times of tight and competitive budgets.

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In setting budgets, many communities may under-budget source reduction programs because when the impacts of a partial program or project are unknown, they are often treated as if the impact is zero. This natural tendency can be problematic in trying to invest in the most effective mix of solid waste programs and efforts, and may lead to higher overall costs than necessary to achieve goals.

However, as communities struggle to find ways to meet aggressive diversion and recycling goals – having already implemented broad-band recycling programs, high-performing yard waste programs, and program inroads into the commercial sector – attention is returning to the potential of source reduction.

- Source reduction – avoiding the costs of collection, processing, and other costs – certainly has the potential to be a tremendously cost-effective method of waste management.

- To date, limited efforts have been made trying to measure savings from two-sided copying, impacts of garage sales and charitable organizations, and other individual efforts.

Source reduction will likely continue to receive lower priority in budgets and program efforts if the level of measurement continues to revolve primarily around ***ad hoc*** or survey-based studies of single business or single-community strategies.

Focus on Variable Rates / Pay as you Throw

The study is focused on exploring whether credible measures of source reduction can be developed. We determined to measure the impacts from a program that would be widely applicable. We decided to see if it was possible to develop an estimate for the source reduction impacts of variable rates (VR) or "Pay as you Throw" (PAYT) incentive programs. Recent work by the author (Skumatz, 1999)[1] has determined that these programs exist in more than 6,000 communities. The research shows that VR / PAYT programs, are in place in all but three states in the U.S., and are available to more than 20% of the U.S. population.[2] If we can measure the source reduction from this program – with applicability to thousands of communities across the nation – we can demonstrate whether source reduction programs can lead to "serious" tons, and whether it looks like it can be a real and cost-effective program.

Under VR/PAYT programs, residents are charged for garbage service based on the number of bags or cans of waste that are collected for disposal. The systems provide an economic incentive to reduce disposal. Methods available to residents include:[3]

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[1] Skumatz, Lisa A., "Update on Variable Rates", Skumatz Economic Research Associates, Inc., Seattle, WA, 1999.
[2] Skumatz, Lisa A., "Update on Variable Rates", Skumatz Economic Research Associates, Inc., Seattle, WA, 1999.
[3] Clearly there are other mechanisms (illegal dumping, etc.) but this has not been found to be a significant problem in variable rates communities and is not include in the discussion. See Skumatz, Van Dusen, and Carton, "Illegal Dumping: Incidence, Drivers, and Strategies", Skumatz Economic Research Associates, Inc. Report Number 9431-1, 1994, and updated in Skumatz articles in *Resource Recycling*.

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- Recycling
- Yard waste diversion and composting, and
- Source reduction.

Previous SERA work[4] has developed estimates of the very significant and strong diversion benefits of variable rates. These studies used statistical analysis to demonstrate that VR/PAYT added another 8-11 percentage points of diversion to existing yard waste and recycling programs – moving communities significantly forward toward 25% and 50% diversion goals. This translates to an increase of 50% or more in recycling, and significant increase in yard waste tonnage in programs, without making other program changes or otherwise enhancing the diversion programs. However, the impacts of VR/PAYT are actually stronger, because, as the study makes clear, source reduction impacts were not accounted for in the estimation work.

VR/PAYT shows particular promise as a venue for measuring source reduction because:

- VR has strong SR incentives, and the large estimated impact from previous work on VR/PAYT's effect on diversion programs indicates there may be potentially large SR impact from VR.
- Data can be assembled to measure the SR impacts of VR/PAYT.
- Demonstrating the impacts on VR/PAYT will be more difficult than measuring the effects from double-sided copying, but demonstrating the effects will make it clear that measurement of more complex SR programs is not impossible.
- Results of measurements from VR/PAYT will be immediately applicable to thousands of communities – potentially helping to increase the credibility of SR programs across the nation.

Source Reduction

We are assuming that source reduction actions by residents include methods to decrease the volume and /or weight of potential wastes, using methods including buying in bulk, buying items with less packaging, re-using items, reusing "junk mail", and a variety of other methods. In this study, we are unable to account for composting separately, so composting will be included in our estimates.

Background research finds that package goods manufactures and distributors have been providing a number of opportunities for consumers to "buy lees packaging". Reports from Proctor and Gamble[5] show that even through MSW increased from 1980 to 1993 because of economic and population increases, grocery packaging as a percent of MSW decreased from 15.3% to 12.1% over the period. Grocery discards in pounds per

[4] Skumatz, Lisa A., Ph.D., "Nationwide Diversion Rate Study – Quantitative Effects of Program Choices on Recycling and Green Waste Diversion: Beyond Case Studies", Skumatz Economic Research Associates Report, Seattle, Washington, 1996, and Skumatz, Lisa A., Ph.D., "Achieving 50% in California: Analysis of Recycling, Diversion, and Cost-Effectiveness", prepared for California Chapters of SWANA, Skumatz Economic Research Associates, Inc., Seattle, WA, 1999.

[5] Keith Zook, Procter and Gamble, personal communication with author.

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person decreased from a high of 175 pounds per person to a projected 116 pounds per person in 2000, a 26% decrease.

Work by Dr. William Rathje from the Garbage Project in Arizona[6] shows that packaging as a percent of landfilled MSW decreased from about 32.5% in the 1980s to 26.5% in the 1990s. This report also demonstrates that the carrying capacity of most packaging materials has increased dramatically. In the 1970s, 23 ounces of product could be packaged per 1 ounce of plastic packaging. By the 1990s, this ratio had improved to 34 ounces of product per ounce of packaging. Similar improvements were found in aluminum, although the ratios for paper, glass, and steel were relatively steady over the period.

Certainly, consumption in a booming economy has led communities to bemoan the additional generation of unnecessary wastes – from junk mail solicitations to excessive packaging to throw-away electronics to non-recycled cars and innumerable other examples. However, given incentives, the hypothesis is that residents in communities with VR/PAYT will value the economic incentives enough to adopt behaviors that reduce disposal. Communities and industry have conspired to provide opportunities for residents to move their waste out of the garbage can and to reduce the amount of waste generated through at least some aspects of their consumption behaviors. Variable rates and PAYT programs provide added incentives for customers to consider making these efforts.

Measurement Approaches

A primary goal of this project was to develop and test alternative methods of measuring source reduction, and then to use them to estimate the reductions from a specific type of program. The idea was that, given that measuring source reduction is challenging in the first place, using multiple methods might allow us to approach the problem from different angles and "triangulate" estimates to develop a credible estimate of the range of source reduction from the program.

We tested two primary categories of measurement methods:

- Cross section, or comparisons between large number of communities at the same point in time; and

- Time series analysis, in which we develop models that estimate the impacts based on causal factors that underlie waste behavior.

In both cases, we estimate the impacts of the program on generation. Then we develop and subtract estimate of the impacts that VR/PAYT has on recycling and yard waste, leaving the source reduction impact as the remainder. This approach uses the fact that

[6] The Garbage Project, "The Archaeology of Plastic Packaging and Source Reduction", prepared for the ULS report, by The Garbage Project, Tucson, Arizona, July 1997.

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the three primary component of generation are recycling, yard waste diversion, and source reduction. The approaches and results are discussed below.

Method 1. Cross-section method: Comparing across multiple communities

SERA has assembled a very large database of program, tonnage, cost, and demographic information from hundreds of communities across the country. This database includes a tremendous diversity of communities including samples of large and small communities, communities from all states, and communities with and without variable rates / Pay as you Throw programs.

Standard evaluation techniques recommend measuring tonnages "before" and "after" the introduction of a program to estimate the program's influences or impacts. An improved technique adds an assessment of the impacts in "control" communities that did not have the program. This extra measurement provides an estimate of what would have happened in the test community if the program hadn't been implemented. That is, this method provides a way to separate out the impacts that might have come from nationwide programs, behavioral changes, weather impacts, or other use of "control groups" to allow the evaluator to separate out the influences of non-programmatic changes over time.[7] The estimate of the program's "net" impact is the total "gross" impact less the changes in the control group's tonnage measures.

One by one program impacts, measuring before vs. after their implementation of variable rates for a single community (matched with one or more control communities), could be one way to conduct this study. However, we would have significant problems from several fronts:

- Many towns have poor information on their tonnages before and after program changes, and the towns have a number of other changes going on during the same time period.

- Finding matched "control towns" is always difficult, because communities differ in so many ways, especially with the range of variations in demographics, recycling programs, etc.

- Most one-by-one approaches would suffer because of small sample sizes. The study would be a glorified example of a "case study" approach, and the results would not be as reliable if large number of communities were used.

For these reasons, we decided to use a simpler, but we believe more robust, approach. We separated SERA's database of more than 1,000 communities into sets of communities that "did" vs. "did not" have VR/PAYT. We then computed an estimate of

[7] See, for example, Skumatz, Lisa A., "Variable Rates in Solid Waste: Implementation, Experience, Economics, and Legislation", Prepared for the Reason Foundation, Study number 160, Los Angeles, CA, 1993, pages 31-35.

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the "generation" per capita, summing the tons from disposal, recycling programs (curbside and drop-off) and yard waste programs (curbside and drop-off).[8]

Using data from hundreds of communities at one point in time achieves several objectives:

- Provides many data points, and large numbers increase the confidence in the results. It avoids the "case study" approach, and makes the results more transferable to a wide variety of communities.

- Using one point in time eliminates the impacts that changes in "other" factors over time may have on generation – for instance, it eliminates the impact from improvements in packaging, etc. All the communities would be measured at approximately the same point in time, with the same opportunities, eliminating the need for additional "control group" estimation techniques.

- The database will include programs that have been in place a long time and a short time (1 to more than 70 years). However, the bulk of the programs were implemented in the 1990s, and the programs should be representative of the communities that might apply these numbers to their programs.

Results

Our estimates found that the sample of communities with variable rates had average generation rates that were 16.1% lower than those in non-VR/PAYT communities.[9] However, we know that this represents a combination of three effects: recycling, yard waste diversion, and source reduction. Estimates of the impacts of VR/PAYT on recycling and yard waste diversion are needed so we can subtract their influence and identify the source reduction impacts of the program.

Very detailed estimates of the impacts of VR/PAYT on recycling and yard waste programs were developed in previous work by the author.[10] This work showed the following effects:

- Increase in recycling program tonnages from VR/PAYT: 5-6 percentage points
- Increase in yard waste program tonnages from VR/PAYT: 4-5 percentage points.

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[8] We used the towns' best estimates of residential waste. As always, we checked the data for outliers and data problems, eliminating data from a few communities.

[9] Higher estimates were developed when we used the simple comparison of variable rates towns to non-variable rates towns. We recognized that other factors than variable rates might differ between the communities. Based on our work in the important drivers for tonnage forecasting (Skumatz, "Forecasting Solid Waste Tonnage: Techniques and Alternatives to Estimate Tonnage, Revenues, Source Reduction, and Program Performance", Skumatz Economic Research Associates, Inc. SERA, Seattle, WA, 1995, 1997), we decided to control for some of these important factors. The reported results came from a model that pulled out the effects of differences in median income and population and rural/urban mix.

[10] Skumatz, Lisa A., Ph.D., "Nationwide Diversion Rate Study – Quantitative Effects of Program Choices on Recycling and Green Waste Diversion: Beyond Case Studies", Skumatz Economic Research Associates Report, Seattle, Washington, 1996

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Therefore, the overall impact of 16 percentage points can be decomposed as follows:

16%	Total effect of VR
5-6%	Minus Recycling effect[8]
4-5%	Minus Yard waste effect[8] yields
5-7%	***Estimated source reduction effects attributable to variable rates/PAYT program per town***

In round figures, these results imply that:

- Variable rates reduces landfilled/disposed tonnage in communities by 16%
- About 1/3 of that goes to increased recycling[8]
- About 1/3 goes to higher yard waste diversion,[8] and
- About 1/3 goes to source reduction, or is never realized (or paid for) by the solid waste management system.

This has important implications for solid waste management in the nation. Franklin Associates[11] estimates the following tonnage for 1998.

Recycled	49,030,000 tons
Yard Waste	13,140,000 tons
Disposed	158,060,000 tons
Generated	220,230,000 tons

Assuming a population of approximately 270 million, and using SERA's estimate that 20% of the U.S. population is covered by VR, we can generate the following estimates of the impacts of VR/PAYT on source reduction – and the potential if more communities adopt these programs.

Current SR from VR/PAYT	***2.64 million tons nationwide***
	1.2% of current generation
	1.7% of disposal

These figures, along with a number of other indicators evaluating the performance of VR/PAYT on source reduction are calculated in more detail in Table 1.

Method 2. Time series method: Estimating behavioral changes and influences

Choices by residents about what types of products to buy, and how to dispose of them are influenced by a wide range of factors. A second method of estimating the size of the impact of variable rates on source reduction uses information on tonnages and influencing factors over a period of time. We can then use statistical techniques to

[11] Franklin Associates, Marge Franklin, personal communication with the author. This firm conducts the updates of MSW tonnages in the U.S. for the U.S. EPA.

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develop a specific quantitative model that tracks the amount of waste disposal behavior explained by each factor. The design of the time series model preferably includes all the key variables that are hypothesized to have an important effect on the amount of tonnage that is generated. In that way, each factor "captures" its own impacts, hopefully independent of the other factors that have been included in the model.

Using some of the same underpinnings as the cross section method, we again assume that waste generation can be decomposed into three major streams – recycling, yard waste diversion, and source reduction. We can develop a model that explains generation, and a factor in the model specifically calls out the influence of the source reduction program of interest (in our case, VR / PAYT). If we then use the model to estimate the current year's generation and also use the model to estimate what generated tonnage would have been without the VR/PAYT program, the result is an estimate of the impact of VR/PAYT on generation.

However, realistically, this estimate of the difference in generation would not only include the source reduction impact, but also would include the impacts of VR/PAYT on recycling and yard waste diversion as well. Therefore, we also need a separate estimate of the impacts of VR / PAYT on these programs. The difference would then provide an estimate of the disposal that "never happened", or the source reduction tonnage of the program.[12]

We developed preliminary estimates of the SR impacts using this alternative approach – a time series model (1960-1998). Several models were developed:

- **"Gross impact"**: We fitted models of generation as function of population, households, employment, gross domestic product (in real dollars), price index, recycling prices, and SERA's estimate of the U.S. population with variable rates over time.[13,14] These results showed that, using 1999 numbers, generation per capita would be 19.7% higher without variable rates. This impact translates to a significant tonnage impact from VR/PAYT.

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[12] A similar approach was discussed and proposed in Skumatz, Lisa A., "Variable Rates in Solid Waste: Implementation, Experience, Economics, and Legislation", Prepared for the Reason Foundation, Study number 160, Los Angeles, CA, 1993, pages 31-35.

[13] The model showed significant coefficients for the variables included. We examined a number of specifications for the model, and looked at subset periods as well. For further discussion of the technique and the relative influence of some of the variables included, see, for example, Skumatz, Lisa A., "Forecasting Solid Waste Tonnage: Techniques and Alternatives to Estimate Tonnage, Revenues, Source Reduction, and Program Performance", Skumatz Economic Research Associates, Inc. SERA, Seattle, Washington, 1995,1997. These evaluation techniques were also discussed in Skumatz, Lisa A., Ph.D., "Variable Rates in Solid Waste: Implementation, Experience, Economics, and Legislation", Prepared for the Reason Foundation, Study number 160, Los Angeles, CA, 1993, pages 31-35.

[14] This is an exploratory paper, not the definitive word on these issues. Clearly, one of the key difficulties with this model is that we had only total generated tonnage available, and did not have the ability to estimate only the residential portion of municipal solid waste (MSW). Previous SERA research had shown that the key factors explaining commercial tonnage or combined county-wide tonnage were combinations of price (preferably of garbage), income, and population, or employment. We felt that variables like gross domestic product would pull out the relevant income effects, and we included combinations of population, households, and employment to control for those types of effects. The included factors had a strong fit, and the most important issue is whether the growth in the U.S. population covered by variable rates/ pay as you throw (the VR indicator we included in the model) is closely related in "shape" or timing to some similar influencing factor for the commercial (or residential) side, which we hoped was not a problem. We had a strong fit with this preliminary/exploratory specification, but more work remains as the model and data available are clearly not perfect.

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- **Impacts controlling for packaging**: However, even though we have controlled for some important factors through the modeling approach (demographics, economics, etc.), other important changes or factors may have been omitted from our model. One of the most important nationwide changes relevant to assigning source reduction influences was downsizing of packaging, which occurred over the same period. Since no packaging factors were yet incorporated into this analysis, the model will tend to overestimate the influence of variable rates on generation. Using work published by the Garbology Project,[15] SERA developed a "packaging index", which indicated the number of ounces of packaging needed to package an ounce of consumer products (weighted across the major packaging materials). Re-estimating the model incorporating this factor,[16] we find that generation would have been 17.3% higher if variable rates had not been in place. *Note that this combination of results may also imply that source reduction from packaging might be responsible for an additional 2.4 percentage points of source reduction.*

- **Separating out recycling and yard waste impacts**: As the third step, we then estimated similar models for recycling and yard waste. The separate influences of variable rates on these tonnage figures was 6.9% of generation for recycling, and 4.6% of generation for yard waste influences. The sum of these impacts (11.5%) can be subtracted from the overall variable rates impact of 17.3%. This provides a figure of 5.8% as the estimate of the source reduction impact of variable rates using this time series method.

This estimate of the impact falls within the range estimated by the cross section method. Approximately 5-7 percentage points seems a reasonable estimate of the SR effects of variable rates using either approach.[17] Given that the figure is a very similar order of magnitude to that estimated using the cross section approach, the computations of tonnages and disposal impacts developed above are equally valid here.

Cost-Effectiveness of Source Reduction and Variable Rates/PAYT

The first part of this exploratory project developed quantitative estimates of the impacts of a source reduction program – one key part of an evaluation. We wanted to try to apply the results to another key evaluation question related to the performance of source reduction – the cost-effectiveness of the program.

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[15] The Garbage Project, "The Archaeology of Plastic Packaging and Source Reduction", prepared for the ULS report, by The Garbage Project, Tucson, Arizona, July 1997.

[16] The estimated coefficients in the revised models were also significant, including the packaging factor.

[17] Alternative estimates: As an alternative approach, we could have used the estimates of recycling and yard waste impacts cited and used in the earlier cross section analysis discussed in the previous section. This approach would have subtracted 9-11 percentage points from the 17.3% overall impact, estimating the SR impact from VR/PAYT as 6.3%-8.3%. Using the time series diversion program numbers with the cross section estimates for diversion programs would lead to an estimate of a 4.6 percentage point impact (16.1-11.5=4.6) for source reduction from variable rates. Note that we developed similar order of magnitude estimates even when modifying the specification of the models somewhat.

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It is difficult to determine how much it costs to implement VR/PAYT. Communities differ in both the systems they have now (and their efficiencies) and the costs will differ depending on the type of system they elect to implement. This can vary dramatically. However, two pieces of information are available.

- Two state surveys[18] note that the majority of communities stated that their costs decreased or stayed the same after they implemented VR/PAYT. Wisconsin found costs decreased in 40% of communities, no change in 27% and increased in 33% of communities. Iowa found that 60% of the communities reported decreased or stable costs. Relatively inexpensive bag, sticker, and hybrid programs are especially popular in these states. Residential solid waste rates between $7 and $12 per month were common for these programs.

- SERA work[19] showed that, in California, where automated can programs are popular, costs for solid waste services increased about 10-20% with the implementation of variable rates. Average monthly garbage and program costs were about $15.40 in the sample. This California estimate is used as a "high" boundary or estimate for the succeeding calculations.

Piecing together this information allow us to generate order-of-magnitude estimates of the cost-effectiveness of variable rates, as shown in Table 1.

[18] See work conducted by the States of Iowa and Wisconsin. See Frable and Berkshire, "Pay as you Waste: State of Iowa Implementation Guide for Unit-Based Pricing", Iowa DNR, Des Moines, Iowa, 1997; and Gruder, "Wisconsin Volume Based Rate Collection Guide", University of Wisconsin Extension, Madison, WI, 1993.

[19] Skumatz, Lisa A., Ph.D., "Achieving 50% in California: Analysis of Recycling, Diversion, and Cost-Effectiveness", prepared for California Chapters of SWANA, Skumatz Economic Research Associates, Inc., Seattle, WA, 1999

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Table 1: Estimated Source Reduction (SR) Impacts of Variable Rates/PAYT Effects on Tonnage, Costs, and Benefit/Cost Ratios

(Source: Skumatz Economic Research Associates, Inc. calculations)

1998	*Base Scenario*: Current Incidence of VR/PAYT	*Scenario 1: Assume* 50% population covered by VR/PAYT	*Scenario 2: Assume* 75% population covered by VR/PAYT	*Scenario 3: Assume* All communities implement VR/PAYT
Generation (in tons, Franklin Associates, 1998)	220,230,000	220,230,000	220,230,000	220,230,000
Population	270,000,000	270,000,000	270,000,000	270,000,000
Gen/capita/year (in lbs)	1,631	1,631	1,631	1,631
VR Red'n (from estimates, this report) for each town	6%	6%	6%	6%
VR incidence (pct pop. Covered, from SERA)[20]	20%	50%	75%	100%
Tons of SR from VR/PAYT	***2,642,760***	***6,606,900***	***9,910,350***	***13,213,800***
Tons of Recycling from VR/PAYT	2,422,530	6,056,325	9,084,488	12,112,650
Tons of Yardwaste from VR/PAYT	1,982,070	4,955,175	7,432,763	9,910,350
Total Disposal diversion from VR	7,047,360	17,618,400	26,427,600	35,236,800
Pct diversion from SR from VR - Total US	***1.2%***	***3.0%***	***4.5%***	***6.0%***
Pct overall diversion from VR - Total US	3.2%	8.0%	12.0%	16.0%
Costs to implement VR -- low estimate (zero per majority of VR/PAYT towns in WI, IA)	0	0	0	0
Costs to implement VR per capita – High estimate (CA, from SERA)[21] per capita	$0.56	$0.56	$0.56	$0.56
Use midpoint of High/Low estimate -- 1/2 low, 1/2 high	$0.28	$0.28	$0.28	$0.28
Costs (times population covered by VR programs)	$12,235,000	$30,587,500	$45,881,250	$61,175,000
Assume avoided landfill costs are $35/ton (excludes transfer/disposal)[22]	$35.00	$35.00	$35.00	$35.00
Avoided LF costs for SR tons	$92,496,600	$231,241,500	$346,862,250	$462,483,000
Avoided LF costs for recycling and YW tons	$154,161,000	$385,402,500	$578,103,750	$770,805,000
Avoided LF for all diverted tons from VR/PAYT	$246,657,600	$616,644,000	$924,966,000	$1,233,288,000
Benefit/cost ratio for SR from VR	7.6	7.6	7.6	7.6
Benefit/cost ratio for recycling and YW from VR*	1.4	1.4	1.4	1.4
Benefit/cost ratio from all avoided tons from VR*	2.2	2.2	2.2	2.2

***Note**: The last two ratios assume $5 per household for recycling and yard waste programs. Excluding these costs generates benefit cost ratios of 12.6 for recycling/yw programs, and 20.2 for all three effects combined.*

[20] Skumatz, Lisa A., "Update on Variable Rates", Skumatz Economic Research Associates, Inc., Seattle, WA, 1999.

[21] Skumatz, Lisa A., Ph.D., "Achieving 50% in California: Analysis of Recycling, Diversion, and Cost-Effectiveness", prepared for California Chapters of SWANA, Skumatz Economic Research Associates, Inc., Seattle, WA, 1999.

[22] This simplification assumes that transfer and some hauling costs would be incurred for recycling and yard waste tons. The simplification also underestimates the savings from source reduction, which requires no hauling or transfer, so these extra savings would properly apply to those tons.

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Applying the Techniques

These estimation techniques can be applied to evaluate other source reduction programs or variable rates in your town or state.

- To apply a cross section type technique (comparing communities at one point in time), you would need information on a set of communities that have implemented the type of program under consideration, and others that have not, so the groups can be separated. You would also like to have a set of demographic, programmatic, and other variables to "pull out" the effects from other differences between the communities and programs.[23]

- In applying time series methods, you would need data from your community or state over a period of time. Key data would be tonnage for the sector of interest, as well as data on factors that influence consumption, recycling, and disposal behavior.[24] You would also want to include some indicators for the variety of programs that were already in place over the period to control for their influence. Most importantly, you will also need some indicator of "when" you put the source reduction program of interest into place, or some indicator of how "intensive" the program was. For example, hypothetically, assume you are attempting to examine the impacts of an extensive business source reduction program that including audits, two-sided copying incentives, and other elements in combination with a "good practices" certification program. For this program, you might include a factor in the model that represents the number of businesses that participated in the program by year (or other period), or how many employees were covered by the businesses that had participated in the program, by year. The statistical modeling work then provides an estimate of the size of the total impact of your program. There may be associated recycling impacts driven by your program (perhaps through increased awareness or program coattail effects). Therefore, you will want to also develop a similar model for the recycling and yard waste impacts, and subtract them to get the "net" source reduction impact of the program.[25] This time series technique goes a step beyond ratios or other methods that don't explicitly "pull out" the influence of other items that affect tonnage generation and behavior, like changes in demographics or economic activity over the period.

The techniques used are basic economic modeling and impact evaluation techniques that have been applied for years to energy conservation programs and other fields. Given the weaknesses of data in solid waste, and the special weaknesses associated with source reduction programs, we were concerned that the project might not be able to

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[23] Comparisons of means are one method that we used. Then, we enhanced the estimate by applying regression analysis so we could formally "control for" the demographic and other differences we believed might exist between the sets of communities. Similar approaches can be applied for other types of source reduction (or other) programs.

[24] A review of forecasting model approaches and the key variables that provided the best "fit" for a variety of sectors (residential, commercial, self-haul, combined, etc.) is included in Skumatz, Lisa A., "Forecasting Solid Waste Tonnage: Techniques and Alternatives to Estimate Tonnage, Revenues, Source Reduction, and Program Performance", Skumatz Economic Research Associates, Inc., Research Report 9599-2, Seattle, Washington, 1995, 1997.

[25] Or compare to actual diversion program tonnages (accounting for natural growth) if all other programs have remained the same.

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detect effects. Instead, we found that, even with imperfect techniques and data, we derived estimates of source reduction that "triangulated" to a fairly consistent number. Although more work can be done to refine the work in this report, the following conclusions can be made:

- Source reduction impacts can be measured.
- They can be measured through a variety of techniques, and the results can be triangulated to develop greater confidence that the order of magnitude estimates are "in the ballpark".
- It is not appropriate to assume that the source reduction impact of programs is unknowable and therefore, effectively zero.

Specifically, these points should be kept in mind when examining budget allocations between source reduction and other types of programs. The results show that impacts can be measured, and when cost-effectiveness is examined using the estimates, source reduction programs can, indeed, be an extremely cost-effective part of the mix of waste management programs.

Conclusions

The project demonstrated that credible economic and statistical techniques could be used to measure source reduction. We used two basic techniques to estimate these impacts:

- Comparisons across communities at one point in time (cross section approach).
- Developing "causal" models to forecast tonnage with and without the program (time series approach).

Both approaches developed similar order of magnitude estimate of the impacts of the source reduction impacts of variable rates – a reduction on the order of 5-7 percentage points of generation.

The results show that there is a significant amount of source reduction currently emanating from the existing variable rates/pay as you throw (VR/PAYT) programs in operation across the US. Even though only 20% of the population is covered by these rate incentive programs, we estimate 2.74 million tons are being source reduced from the existing VR/PAYT communities. This means that, to date, disposal has been reduced by 1.7% and generation by 1.2% nationwide from just the source reduction impacts of these existing programs. Adding in the recycling and yard waste benefits from VR / PAYT programs significantly increases the tonnage (and avoided costs) from implementing VR/PAYT.

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The research shows that 5-7 percentage points of additional diversion can be attributed to each community that has implemented a VR/PAYT program. This is an estimate of the diversion strictly from the source reduction (SR) impacts of the programs. For each community, the total VR/PAYT-caused diversion is 16%, including the extra recycling and yard waste diversion from the program. The estimates also mean that, to date, nationwide residential disposal has been reduced by 1.7% and generation is 1.2% lower nationwide from just the source reduction impacts of existing VR/PAYT programs

***Example**: Town A starts with 100,000 tons of waste disposed*

Town A will expect to see about 5,000-7,000 tons less disposal (increased diversion) from source reduction alone if they implement VR/PAYT. (100,000 TPY times 0.05 to 0.07)

Adding the estimated increases in recycling and yard waste diversion, Town A's total disposed tonnage would fall by 16,000 tons. (100,000 times 0.16)

Town A's disposal before:	*100,000 tons*
Reduction from SR from PAYT:	*5-7,000 tons*
Town's total disposal after all PAYT impacts:	*84,000 tons*

These impacts are separate from or in addition to the existing levels of recycling or other diversion from existing programs.

Each town implementing variable rates can expect to see total new reductions in disposal on the order of **16%,**[26] with 1/3 going to increased recycling, 1/3 to increased yard waste diversion, and about 1/3 being avoided entirely through source reduction.[27] ***We estimate that 5-7 percentage points of additional diversion can be realized in a town from the source reduction impacts of variable rates/pay as you throw programs.***

The cost savings from the source reduction influence are very high. Even using approximations, computations of benefit cost (B/C) ratios show source reduction from VR/PAYT has a B/C ratio on the order of 7.6 – and that assumes the entire cost of the VR/PAYT program is "assigned" to the source reduction program. Ratios of greater than 1 are usually considered good investments (they "pay back" in a year or less). Compared to recycling and yard waste programs, this is a very high payback. The benefit cost ratio from all tonnage impacts (recycling, yard waste, and SR), incorporating all program costs, is still estimated as over 2.2 in the example using the assumptions provided.[28]

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[26] It is important to understand that this 16% estimate means that if your town adds a new variable rates / pay as you throw program on top of existing recycling or yard waste programs, your residential disposal should fall by another 16% over what it would have been without the addition of the VR/PAYT program. You would expect to see 5-6 percentage points to be added to your existing recycling program, and 4-5 percentage points added to your yard waste program – on top of the diversion you were previously getting. VR/PAYT boosts participation and capture from these programs, and note that your programs don't have to be City-sponsored, nor do they have to be curbside to see this kind of effect. The final effect, the one we were trying to estimate in this report is the "free" benefit from source reduction impacts from VR/PAYT. Based on the analysis in this report, we estimate that this will be responsible for decreasing your residential disposal by about 5 to 7 percentage points. If you add a recycling program or yard waste program at the same time you introduce the VR/PAYT program, your total impact on disposal would be larger than these estimates. They would be 16% plus normal recycling or yard waste program effects.

[27] These are "round" figures for illustration purposes. The accurate figures were shown elsewhere in the report – 5-6% to recycling, 4-5% to yard waste diversion, and the remaining 5-7% is source reduction. Skumatz, Lisa A., Ph.D., "Nationwide Diversion Rate Study – Quantitative Effects of Program Choices on Recycling and Green Waste Diversion: Beyond Case Studies", Skumatz Economic Research Associates, Inc. Report, Seattle, Washington, 1996.

[28] These benefit/cost ratio figures may serve as approximate inverses of the payback calculations. Two assumptions are needed: that most of the costs of putting in the variable rates program is first-year implementation cost, and that the economic incentive

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Given that recycling programs alone do not encourage source reduction, the investment in a variable rates or PAYT program has significant advantages including:

- High levels of source reduction,
- Environmental benefits, strong program paybacks, and
- Additional recycling and yard waste diversion impacts that provide significant progress toward meeting diversion goals.

VR/PAYT programs have a myriad of benefits, including equity, education, and increasing recycling and yard waste diversion. However, because the magnitude was not known, the source reduction benefits were have usually been ignored. In this project, we find that these source reduction benefits are high on a per-community basis and have already led to significant source reduction diversion at the national level. Source reduction programs are valuable, are measurable, and lead to significant savings and a more cost-effective overall mix of solid waste management programs. All things considered, policymakers and community decision-makers can now know that source reduction's payback means investing in source reduction can be a very good waste management bargain.

"sticks" – that each year users keep their generation down in response to the rates. There is strong evidence for both conclusions. In this case, the payback period for the SR from VR/PAYT would be $12.2 million cost to implement VR/$92.5 million avoided costs for SR or .13 years (or 45 days). Payback periods for the recycling and yard waste programs, and for the combination of all three programs are also estimated at less than one year. These programs also move communities a long way toward 50% recycling goals.

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